**Noise Reduction Through Planting of Shrubs on Railway Bridge Approaches**

Ulugbek Shermukhamedov1, a), Fakhriddin Zokirov1, b), Sharofat Kadirova1, c),  
Ganisher Malikov1, d) and Lintang Dian Artanti2, e)

*1Tashkent State Transport University, 1 Temiryulchilar St., Tashkent 100167, Uzbekistan 2Jakarta Global University, Jakarta, Indonesia*

*a) Corresponding author:* [*ulugbekjuve@mail.ru   
b*](mailto:ulugbekjuve@mail.ru%20b)*)*[*0202031@inbox.ru*](mailto:0202031@inbox.ru) *c)*[*kadirovash@tstu.uz*](mailto:kadirovash@tstu.uz) *d)*[*ganisherm@inbox.ru*](mailto:ganisherm@inbox.ru) *e)lintang@jgu.ac.id*

**Abstract.** The issue of mitigating noise pollution generated by high-speed trains has become a critical concern within the field of modern transportation infrastructure. Excessive noise not only affects human health and well-being but also disrupts the surrounding environment. This article explores innovative, technology-based approaches aimed at reducing the adverse effects of railway noise. In particular, the study focuses on the strategic planting of shrubs along bridge approach embankments as an effective, nature-based solution. Shrubs function as natural noise barriers that can significantly attenuate sound waves, thereby lowering the noise levels experienced by nearby communities. Beyond their acoustic benefits, shrubs also play a vital role in strengthening embankment soil, preventing erosion, and promoting ecological stability by supporting local biodiversity. Theoretical modeling and simulation results presented in the article demonstrate that the presence of dense shrubbery along embankments substantially decreases the distance and intensity of noise propagation. Consequently, this green infrastructure solution provides both environmental and social benefits, highlighting its potential for widespread implementation in modern railway design and urban planning.

**Keywords:** Approach bridges, energy-absorbing technologies, ground mass, high speed, highway bridges, noise propagation, shrub vegetation

**INTRODUCTION**

High-speed rail (HSR) systems refer to high-tech train technologies but are defined by the fact that they move at a high rate of speed in relation to regular trains, usually by the implementation of unique designs and specially designed infrastructure. The existence of such systems is linked to the high ranking of acoustic emissions, they consume a lot of energy, and need an aerodynamic optimized track and station construction.

The key peculiarities of high-speed trains (HSTs) are its velocity values, which are frequently more than 250 km/h in general regular working conditions and 600 km/h in laboratory conditions [1, 5]. Other countries like Japan (Shinkansen), China (CRH), France (TGV) and Germany (ICE) are the world leaders in HSR technology in which these trains are effective intercity connections.

Implementation of the high-speed rails leads to significant socio-economic values such as saving time spent on traveling between cities, improving the effectiveness of the transport network, and improving overall population mobility and promoting sustainable development in terms of less carbon dioxide emissions. HSTs which are powered electrically are very energy efficient and tend to perform better than other forms of transport in relation to the minimization of environmental impact [2, 13].

Nevertheless, high velocities bring one of the worst problems in the high-speed rail operation, i.e. aerodynamic noise generation and rolling noise generation mainly due to the airflow disturbance and wheel-rail interaction. When this noise is more than 85 decibels (dB) it may be very unhealthy to people and disrupts the ecological set ups. To reduce these effects modern HSR systems are integrating more and more noise-reduction requirements, including acoustic insulation, sound-absorbing screens, vibration-resistant track ways and resonance-controlled structural systems [11, 12].

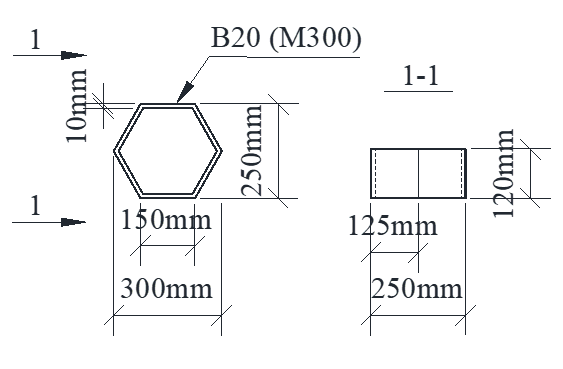
On-going research and development in acoustic engineering and planning of sustainable infrastructure is vital in order to make sure that the advantages of high-speed rail are achieved without harming the quality of the environment and the health of the people.

**MATERIALS AND METHODS**

The noise level of high-speed trains can usually be between 90÷110 dB. This level of noise directly depends on the type of train (passenger or freight), its speed, the quality of the road infrastructure and the environment. As the speed of the train increases, the noise level increases accordingly. That is, for trains moving at a speed of 250 km/h, the noise level is usually 85÷90 dB, and at speeds of 300 and 350 km/h, it is 90÷95 dB and 95÷105 dB, respectively. Noise can be even more intense near obstacles (buildings) [2, 3]. To reduce noise, engineers can mainly achieve this by optimizing wind flow (by reducing resistance to flow), creating green areas around high-speed lines (plants and special sound barriers can reduce the noise level emitted into the environment by 10÷15 dB), and constructing barriers, using noise-absorbing materials, and noise-control devices.

In our country (the Republic of Uzbekistan), a high-speed train service connecting the cities of Tashkent and Samarkand has been launched since 2011. The length of this railway line is 344 km, and the Talgo (“Afrosiyob”) high-speed train covers the distance between Tashkent and Samarkand in 120 minutes [2, 3, 4, 5, 8]. If the Afrosiyob train has a speed of 250 km/h, then, as we noted above, the noise level is 85÷90 dB. In turn, taking into account the negative impact of such a level of noise on human health and the environment, there is a need for innovative technological solutions to reduce noise and the construction of noise-reducing structures on this line. Therefore, several measures (noise-reducing barriers) have been implemented to reduce noise on the Tashkent-Samarkand high-speed train line. While these measures may be effective in reducing noise, they may not be sufficient to the extent specified in regulatory documents. To increase the effectiveness of noise reduction measures, it is proposed to construct special engineering structures on the approach bridges of the bridge structures located on this line [6, 7, 12]. The results of an experimental theoretical study on reducing noise and increasing the strength of the soil mass in the approach girder of the bridge structure located on the Tashkent-Samarkand high-speed line, which was selected as the object of the study, are presented.

According to this proposed method, hexagonal reinforced concrete structures are laid on the approach risers of the structure (Figure 1).

****

**FIGURE 1.** View of a hexagonal reinforced concrete structure

The concrete grade of this structure is B20 (M300), and the reinforcement frame consists of AI Ø6.5mm reinforcement. To ensure the specified strength, the concrete mix is prepared based on the correction determined by the laboratory (Table 1).

**TABLE 1.** Composition of concrete mix for construction samples (calculation)

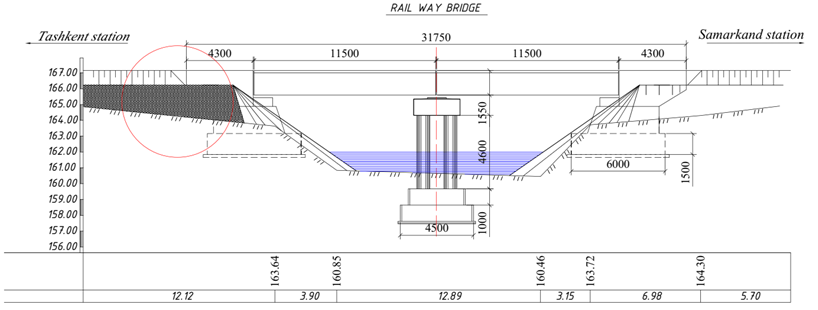
|  |  |  |
| --- | --- | --- |
| Naming | Oneness | В20 (M-300) |
| Standard cost |
| Cement | t | 0,380 |
| Sand | m3 | 0,679 |
| Crushed stone | m3 | 0,507 |
| water | m3 | 0,147 |

*\*These data are given for 1 m3 of concrete mix.*

The installation of finished structures on the bridge approach bridge is carried out in the following stages.

At the planning and design stage, project documentation and working drawings are developed. The mutual arrangement of structural modules and the drainage system are selected.

During the construction and assembly phase, the structural modules are assembled on the bridge approach girder. Each element is checked for compliance with the dimensions specified in the working drawings, and then the elements are interconnected (Figure 2).



**FIGURE 2.** Location of hexagonal reinforced concrete structures on bridge approach girders (marked with a red circle)

**RESULTS AND DISCUSSION**

After the construction modules are assembled, they are filled with high-yield soil (a soil mixture containing plant seeds and nutrients). Irrigation and drainage systems are installed and all systems are checked to ensure that they are installed as specified in the project. During the assembly of hexagonal construction modules, many technical and environmental aspects must be taken into account. That is, the correct selection of construction materials, plants, construction equipment and methods, as well as the use of technologies aimed at reducing noise and ensuring the superiority of approach lifts, are important [9, 11].

The calculation of the effectiveness of shrubby plants in reducing noise is based more on acoustic and ecological factors. In order for plants and shrubs to be effective in absorbing, diffusing or absorbing noise, several factors must be taken into account, such as the height of the plants, their density, the size and shape of their leaves, and their location.

The noise reduction efficiency of shrubs is described by the “Noise Reduction Coefficient” (NRC) or “Sound Absorption Coefficient”. For plants, this coefficient is calculated as follows:

|  |  |
| --- | --- |
|  | (1) |

|  |  |
| --- | --- |
| Here | – absorbed sound level; |
|  | – the amount of sound energy absorbed by the plant (absorbed sound); |
|  | – The amount of sound generally affected by the plant. |

This formula is used to calculate how effectively plants or shrubs absorb sound.

Plants can create an acoustic barrier, reducing noise.

|  |  |
| --- | --- |
|  | (2) |

|  |  |
| --- | --- |
| Here | – noise level reduction (dB); |
|  | – the amount of sound energy absorbed by plants (in square meters or other units of measurement); |
|  | – the initial amount of noise (dB) or source noise. |

When determining the noise reduction effectiveness of shrubby plants, factors such as plant density, height, and compactness (i.e., the size and spread of the leaves) are taken into account.

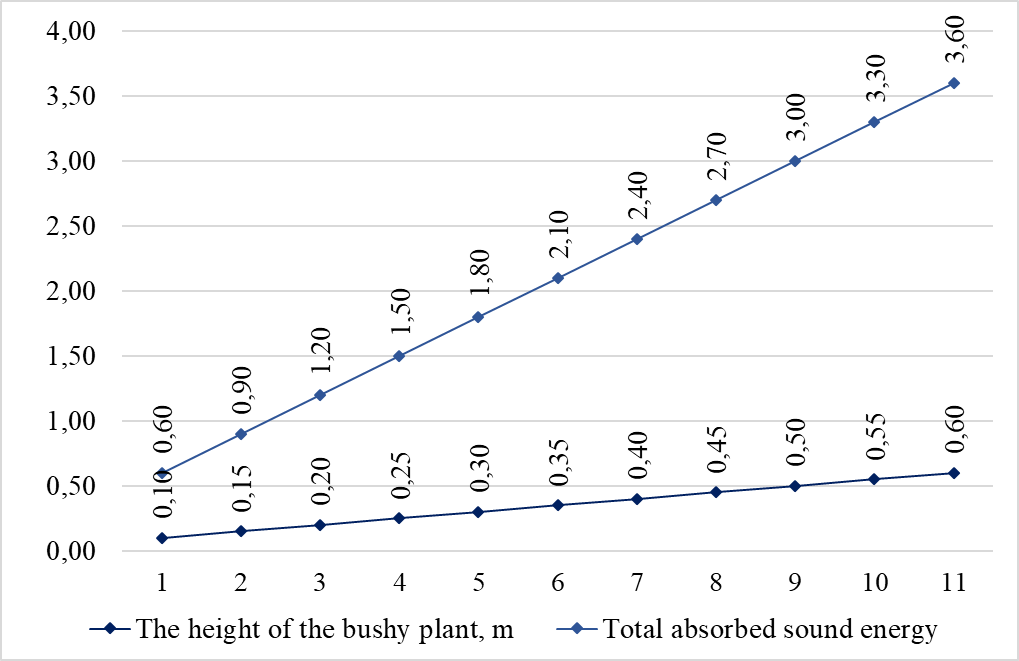
|  |  |
| --- | --- |
|  | (3) |

|  |  |
| --- | --- |
| Here | – plant height (m); |
|  | – plant density (i.e., the total number of plants per 1m2). |
|  | – distance to the noise source (m). |

**TABLE 2.** Effect of shrub height on noise energy absorption

|  |  |  |  |
| --- | --- | --- | --- |
| № | Height of shrub, m | Density of shrubby plant, m2/unit | Total absorbed sound energy |
| 1 | 0.10 | 10 | 0.6 |
| 2 | 0.15 | 10 | 0.9 |
| 3 | 0.20 | 10 | 1.2 |
| 4 | 0.25 | 10 | 1.5 |
| 5 | 0.30 | 10 | 1.8 |
| 6 | 0.35 | 10 | 2.1 |
| 7 | 0.40 | 10 | 2.4 |
| 8 | 0.45 | 10 | 2.7 |
| 9 | 0.50 | 10 | 3.0 |
| 10 | 0.55 | 10 | 3.3 |
| 11 | 0.60 | 10 | 3.6 |

We can see that the amount of sound energy absorbed by shrubby plants increases as their height increases from 10 cm to 60 cm (Figure 3).



**FIGURE 3.** The relationship between the height of a shrub and the level of noise energy absorption

From Figure 3 above, we can see that the energy absorption capacity of the shrubby plants increases depending on the height, density, and distance from the noise source of the noise generated by the movement of high-speed trains [10, 14, 15, 16]. Also, these shrubby plants are important not only in absorbing noise energy, but also in increasing the superiority of the approach bridges of the bridge structure [18].

The degree of consolidation of the soil mass of shrubby plants varies depending on the condition of their root system.

|  |  |
| --- | --- |
|  | (4) |

|  |  |
| --- | --- |
| Here | – soil reinforcement level; |
|  | – the strength of the plant's root system (varies depending on the plant type and growth stage, 0.05-0.2); | |
|  | – plant height; |
|  | – radius of the root system of plants, R=0.5H. |

The effectiveness of shrubby plants in increasing soil strength is determined as follows.

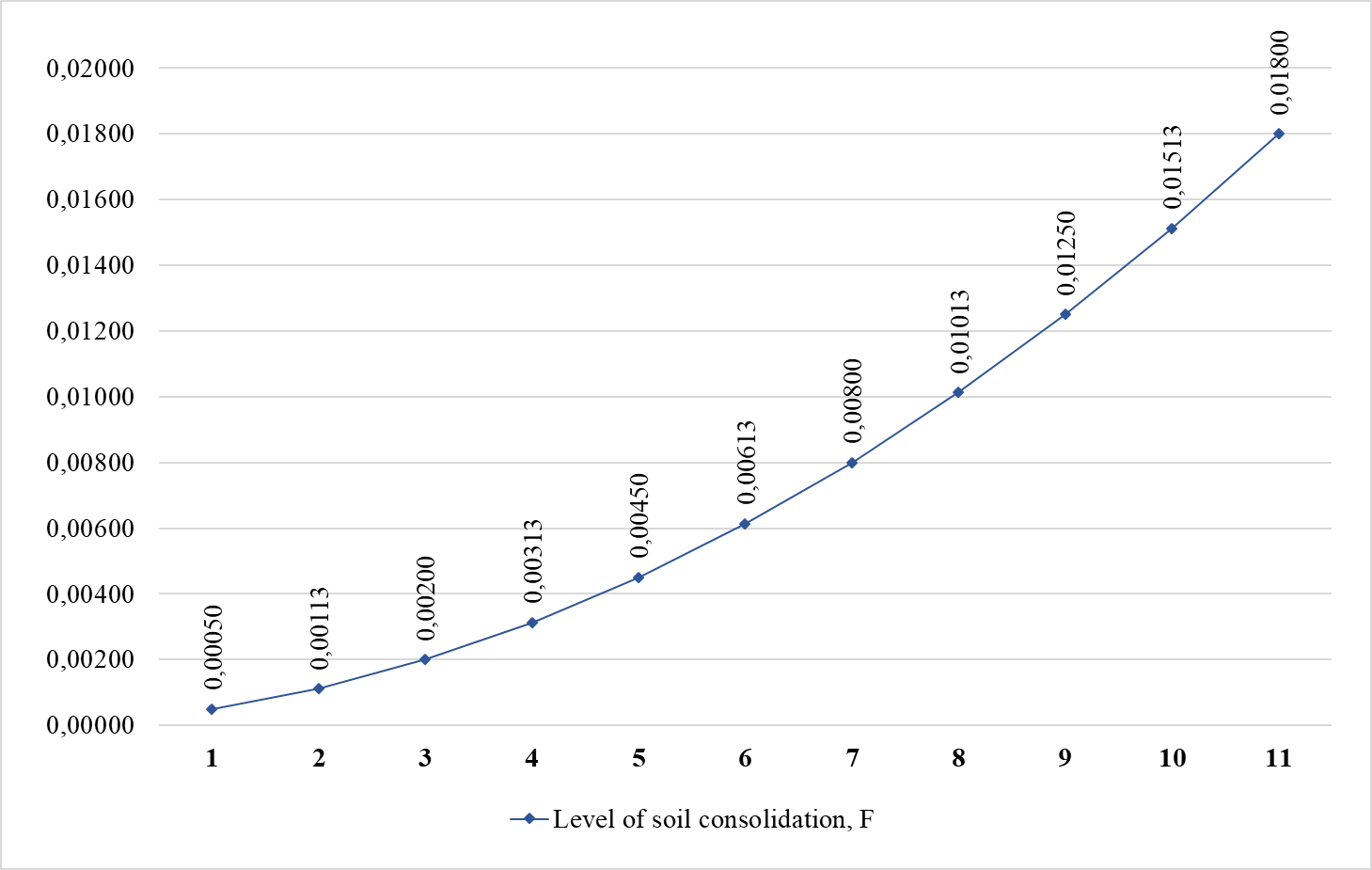
|  |  |
| --- | --- |
|  | (5) |

|  |  |
| --- | --- |
| Here | – soil reinforcement efficiency; |
|  | – the strength of the plant's root system (varies depending on the plant type and growth stage); |
|  | – plant height; |
|  | – radius of the root system of plants. |

In this case, the height of the shrub and the width radius of the root system are the main factors in increasing the strength of the soil massif (Table 3).

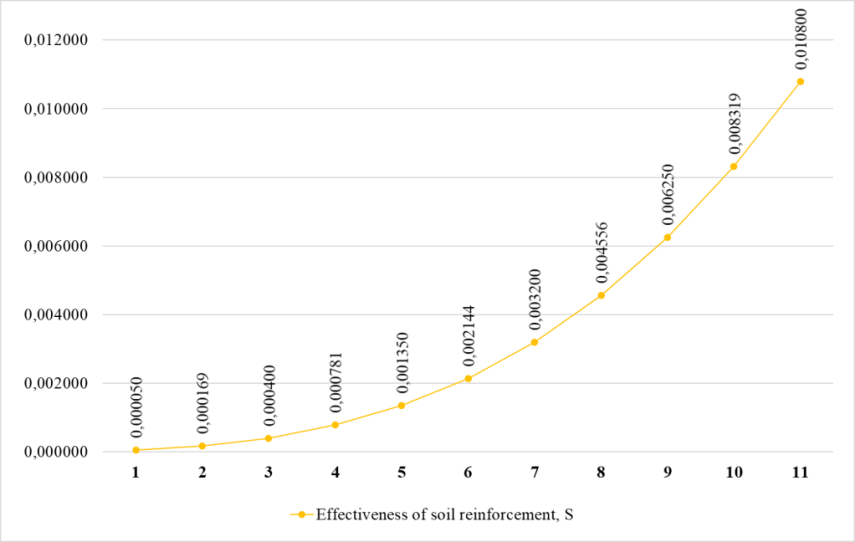
**TABLE III.** The effect of shrub height on soil strength

|  |  |  |  |
| --- | --- | --- | --- |
| № | The height of the bushy plant, m | Level of soil consolidation, F | Effectiveness of soil reinforcement, S |
| 1 | 0,10 | 0,00050 | 0,000050 |
| 2 | 0,15 | 0,00113 | 0,000169 |
| 3 | 0,20 | 0,00200 | 0,000400 |
| 4 | 0,25 | 0,00313 | 0,000781 |
| 5 | 0,30 | 0,00450 | 0,001350 |
| 6 | 0,35 | 0,00613 | 0,002144 |
| 7 | 0,40 | 0,00800 | 0,003200 |
| 8 | 0,45 | 0,01013 | 0,004556 |
| 9 | 0,50 | 0,01250 | 0,006250 |
| 10 | 0,55 | 0,01513 | 0,008319 |
| 11 | 0,60 | 0,01800 | 0,010800 |



**FIGURE 4.** The effect of vegetation height on the strength of the soil mass on bridge approach embankments

From the data presented in Table 3, we can see that the bridge showed a positive correlation between the increase in the height of shrubby plants located on the approach abutments and the strength of the soil mass [3, 7, 17]. In this case, when the amount of shrubby plants is 10 cm, the strength of the approach abutment soil mass is 0.00050 and its efficiency is 0.000050. An increase in the height of the shrubby plant also causes an increase in the radius of its root system. As a result, when the height of the shrubby plant increases by 6 times (when it becomes 60 cm), the strength of the bridge approach abutment soil mass and the efficiency index increase by 36 and 216 (0.01800 and 0.010800), respectively (Figures 4, 5).



**FIGURE 5.** The effectiveness of vegetation height on the strength of the soil mass on bridge approach embankments

**CONCLUSION**

Resting on the results of a study carried out to reduce noise pollution caused by high-speed rail traffic and increase the geotechnical stability of the approach embankments of the bridge structure along the Tashkent Samarkand high-speed railway line, it has been determined that the efficacy of noise reduction is essentially based on the height and spatial density of the shrub-type vegetative cover. In addition, the sound source-vegetation barrier proximity is very essential in the acoustic effectiveness of the vegetation barrier. Besides dampen up and down sounds, another way in which the shrubs enhance the structural integrity and long term stability of the embankment is in their contribution to making the soil mass more mechanically stable and erosion-resistant.

Additionally, the rooting systems of shrubs that are densely planted enhance the stickiness of soil and help to eliminate surface erosion that occurs due to the emergent factors that include precipitations and winds. They constitute an inbuilt system of reinforcement, making the embankment slopes more shear-resistant and minimizing the possible deformation or collapse during cyclic deformations acting on it with rail traffic. Also, the vegetation helps introduce micro climate control around the infrastructure due to the lowering of temperatures on the surface and raising humidity which can, beneficially, affect the structural material and the ecosystem around the infrastructure as secondary effect. In a sustainable approach, the combination of green barriers like shrubs in the design of infrastructure has two-fold purpose: the mitigation of the environment and the strengthening of structures. Thus, it is suggested that vegetative factors should be integrated in the process of planning and sustaining the approach embankments under railways as an environmentally acceptable and economical way of problem solving.

**FUTURE SCOPE**

The aim of further studies may become the search of particular kinds of shrubs that attenuate rail noise most effectively. With the machine learning and AI-based systems of plant classification, researchers will be able to evaluate acoustic characteristics of different kinds of shrubs and make the most efficient ones recommendations to reduce the noise, stabilizing the soil, and adapting to the climate conditions.

It might be possible to install shrub-noise mitigation system as part of intelligent transportation infrastructure. The sensors installed in the planted areas would be able to detect noise, moisture and plant health in the planted areas in real time so that action may be taken before things start to go wrong.

To be pursued in the future potential solutions might be god hybrid solutions, where shrub planting is being combined with acoustic absorbing materials, vertical green walls, and constructed embankments. In high-speed areas or in a terrain where there is your railway, the noise is reinstated, this can be given levels of protection through such combinations.

With the alterations in the growth of vegetation caused by climate change, there will be a necessity to build and choose shrub species that will stand harsh weather conditions and that produce acoustic performance. Variable varieties that are drought-proof and pollution resistant will be of particular pertinence to dry or city conditions.

The approach can be adapted to the urban rails: metros and light rails. The implementation of shrub-based green infrastructure in cities will not only be noise fighting, but in addition to the cleaner air, its appearance will take on a better appearance, and there will be an aspect of life of city biodiversity.

It is possible to develop the regulation and environmental standards that contain shrub-based sound barriers as the part of the sustainable design of the railway infrastructure. Such implementations could be required or encouraged by governments and transportation authorities of new constructions and those already established highways and railroads.

The consequences of the shrub planting are measurable in connection to the ecological and the acoustic effect of the shrub planting by doing longitudinal studies. This would aid in determining how long their noise reduction effect would last, and what contribution they would make towards habitat creation, capture of carbon and erosion removal.

In future studies, they can come up with in-depth economic specification to compare the expenditure of the shrub based noise reduction with other conventional means like concrete shields. Such models might include benefits of a long-term benefit like reduction in cost of maintenance, better environmental condition and satisfaction of a community.

Future studies can assess the effects of planting shrubs on the object that goes beyond the areas of noise reduction. Research could cover the perception of the public, the aesthetic value, and the psychological advantages of green areas close to transport streets.

Finally, adjustable design patterns that support shrub noise reduction can be formed to help in the worldwide roll-outs. Unique guidelines based on geographical and climatic conditions would facilitate the effective implementation of this nature based solution by the railway authorities in other parts of the world.

**REFERENCES**

1. Z. Zhang, A. Ashour, W. Ge, Z. Ni, H. Jiang, S. Li, and D. Cao, “Experimental investigation on flexural performance of steel-UHPC composite beams with steel shear keys,” Engineering Structures **313**, 118275 (2024).
2. Y. W. Gu, X. Nie, A. G. Yan, J. H. Zeng, Y. F. Liu, and Y. X. Jiang, “Experimental and numerical study on vibration and structure-borne noise of high-speed railway composite bridge,” Applied Acoustics **192**, 108757 (2022).
3. S. S. Salixanov, F. Z. Zokirov, Y. T. Khakimova, and G. B. Ismailova, “The effect of increasing loads on foundations of operating bridges,” E3S Web of Conferences **401**, 01080 (2023), <https://doi.org/10.1051/e3sconf/202340101080>.
4. S. Salikhanov, Z. Pulatova, F. Zakirov, Z. Rahimjonov, and A. Abdullayev, “Determination of deformations and self-stress in concrete on stress cement,” E3S Web of Conferences **264**, 02056 (2021), <https://doi.org/10.1051/e3sconf/202126402056>.
5. C. Raupov, A. Karimova, F. Zokirov, and Y. Khakimova, “Experimental and theoretical assessment of the long-term strength of lightweight concrete and its components under compression and tension, taking into account the macrostructure of the material,” E3S Web of Conferences **264**, 02024 (2021), <https://doi.org/10.1051/e3sconf/202126402024>.
6. X. Zhang, X. Zhang, J. Yang, S. Zhu, and Q. He, “Mechanism of noise reduction caused by thickening top plate for high-speed railway box-girder bridge,” Structures **57**, 105148 (2023).
7. S. Shayakhmetov, et al., “Seismic stress state of ‘Earth bed–foundation’ system,” E3S Web of Conferences **401**, 01083 (2023), <https://doi.org/10.1051/e3sconf/202340101083>.
8. G. A. Khalfin, et al., “System for determining state of continuous welded track,” E3S Web of Conferences **401**, 02050 (2023), <https://doi.org/10.1051/e3sconf/202340102050>.
9. C. Raupov and G. Malikov, “Comparison of microcrack formation boundaries determined by complex of physical methods with long-term strength of expanded clay concrete under different types of stress state,” E3S Web of Conferences **365**, 02023 (2023), <https://doi.org/10.1051/e3sconf/202336502023>.
10. V. Tsoy, F. Karimova, N. Mukhammadiyev, and J. Turgayev, “Parameters of the oscillatory process of the sleeper base in the area of the rail joint when using elastic spacers,” E3S Web of Conferences **401**, 05078 (2023), <https://doi.org/10.1051/e3sconf/202340105078>.
11. A. Choiri, M. S. Yusuf, R. N. Sari, L. D. Artanti, and A. A. Hapsari, “Comparison of road damage analysis using PCI method and Bina Marga method and the analysis of road improvement methods using the road pavement design manual (Case study: Citayam–Parung road),” E3S Web of Conferences **479**, 07017 (2024), <https://doi.org/10.1051/e3sconf/202447907017>.
12. S. Avezov, D. Yunusova, O. Yusupjonov, M. Kazakbaeva, R. Gulmurzaeva, U. Saksonov, O. Ruzikulova, and S. Djumabaeva, “Quantifying water bodies with Sentinel-2 imagery and NDWI: A remote sensing approach,” E3S Web of Conferences **590**, 02007 (2024), <https://doi.org/10.1051/e3sconf/202459002007>.
13. C. Raupov and G. Malikov, “Creep in expanded clay concrete at different levels of stress under compression and tension,” E3S Web of Conferences **365**, 02008 (2023), <https://doi.org/10.1051/e3sconf/202336502008>.
14. K. Salyamova and S. Kadirova, “Strength assessment of tunnel lining considering soil conditions,” BIO Web of Conferences **141**, 02021 (2024), https://doi.org/10.1051/bioconf/20249302021.
15. M. Miralimov and S. Normurodov, “Ground behaviour and settlements analysis on tunnelling of shallow-buried metro in Tashkent city,” E3S Web of Conferences **401**, 01062 (2023), <https://doi.org/10.1051/e3sconf/202340101062>.
16. M. Miralimov, S. Normurodov, M. Akhmadjonov, and A. Karshiboev, “Numerical approach for structural analysis of metro tunnel station,” E3S Web of Conferences **264**, 02054 (2021), <https://doi.org/10.1051/e3sconf/202126402054>.
17. S. T. Djabbarov and R. H. Mukarramov, “Influence of engineering and geodynamic processes on stability of transport infrastructure,” E3S Web of Conferences **401**, 01082 (2023), https://doi.org/10.1051/e3sconf/202340101082.
18. S. T. Djabbarov and R. H. Mukarramov, “Monitoring and forecasting of hazardous geological processes using a 3D scanning system,” AIP Conference Proceedings **2432**, 01000 (2022).